

What is claimed is:

1 1. A program debugger, for use in a programming environment, comprising:
 2 means for extracting, from an initial conditional breakpoint within a program
 3 loop, a first Boolean expression that is at least partially invariant within the loop;
 4 means for removing said initial conditional breakpoint;
 5 means for setting, at a pre-ICB program position, a special conditional
 6 breakpoint that includes said first Boolean expression; and
 7 means for reestablishing said initial conditional breakpoint if said special
 8 conditional breakpoint is satisfied.

1 2. The program debugger of claim 1, wherein said first Boolean expression is
 2 completely invariant within the loop.

1 3. The program debugger of claim 1, further comprising:
 2 means for setting, at a first loop exit program position, a first reset breakpoint;
 3 and
 4 means for removing said initial conditional breakpoint if said first reset
 5 breakpoint is satisfied.

1 4. The program debugger of claim 3, further comprising:
 2 means for removing said first reset breakpoint if said first reset breakpoint is
 3 satisfied.

5. The program debugger of claim 3, further comprising:

means for setting, at a second loop exit program position, a second reset breakpoint; and

means for removing said initial conditional breakpoint if one of said first and second reset breakpoints is satisfied.

6. The program debugger of claim 5, further comprising:

means for removing said first and second reset breakpoints if one of said first and second reset breakpoints is satisfied.

7. The program debugger of claim 1, further comprising:

means for extracting, from program code within the loop, a second Boolean expression that is invariant within the loop,
wherein said special conditional breakpoint disjunctively includes the complement of said second Boolean expression, and said first Boolean expression is invariant within the loop when said second Boolean expression is satisfied.

8. The program debugger of claim 7, further comprising:

means for setting, at a first loop exit program position, a first reset breakpoint; and

means for removing said initial conditional breakpoint if said first reset breakpoint is satisfied.

9. The program debugger of claim 8, further comprising:

means for removing said first reset breakpoint if said first reset breakpoint is satisfied.

10. The program debugger of claim 8, further comprising:

means for setting, at a second loop exit program position, a second reset breakpoint; and

means for removing said initial conditional breakpoint if one of said first and second reset breakpoints is satisfied.

11. The program debugger of claim 10, further comprising:

means for removing said first and second reset breakpoints if one of said first and second reset breakpoints is satisfied.

12. A method of reducing debugger impact through conditional breakpoint motion, comprising:

extracting, from an initial conditional breakpoint within a program loop, a first Boolean expression that is at least partially invariant within the loop;

removing said initial conditional breakpoint;

setting, at a pre-ICB program position, a special conditional breakpoint that

includes said first Boolean expression; and

if said special conditional breakpoint is satisfied, reestablishing said initial conditional breakpoint.

1 13. The method of claim 12, wherein said first Boolean expression is
2 completely invariant within the loop.

1 14. The method of claim 12, further comprising:
2 setting, at a first loop exit program position, a first reset breakpoint; and
3 if said first reset breakpoint is satisfied, removing said initial conditional
4 breakpoint.

1 15. The method of claim 14, further comprising:
2 if said first reset breakpoint is satisfied, removing said first reset breakpoint.

1 16. The method of claim 14, further comprising:
2 setting, at a second loop exit program position, a second reset breakpoint; and
3 if one of said first and second reset breakpoints is satisfied, removing said
4 initial conditional breakpoint.

1 17. The method of claim 16, further comprising:
2 if one of said first and second reset breakpoints is satisfied, removing said first
3 and second reset breakpoints.

1 18. The method of claim 12, further comprising:
 2 extracting, from program code within the loop, a second Boolean expression
 3 that is invariant within the loop,
 4 wherein said special conditional breakpoint disjunctively includes the
 5 complement of said second Boolean expression, and said first Boolean expression is
 6 invariant within the loop when said second Boolean expression is satisfied.

1 19. The method of claim 18, further comprising:
 2 setting, at a first loop exit program position, a first reset breakpoint; and
 3 if said first reset breakpoint is satisfied, removing said initial conditional
 4 breakpoint.

1 20. The method of claim 19, further comprising:
 2 if said first reset breakpoint is satisfied, removing said first reset breakpoint.

1 21. The method of claim 19, further comprising:
 2 setting, at a second loop exit program position, a second reset breakpoint; and
 3 if one of said first and second reset breakpoints is satisfied, removing said
 4 initial conditional breakpoint.

1 22. The method of claim 21, further comprising:
 2 if one of said first and second reset breakpoints is satisfied, removing said first
 3 and second reset breakpoints.

23. An article of manufacture comprising a computer program medium
readable by a computer and embodying one or more instructions executable by the
computer to perform a method of reducing debugger impact through conditional
breakpoint motion, the method comprising:
extracting, from an initial conditional breakpoint within a program loop, a first
Boolean expression that is at least partially invariant within the loop;
removing said initial conditional breakpoint;
setting, at a pre-ICB program position, a special conditional breakpoint that
includes said first Boolean expression; and
if said special conditional breakpoint is satisfied, reestablishing said initial
conditional breakpoint.

24. The article of manufacture of claim 23, wherein the first Boolean
expression is completely invariant within the loop.

25. The article of manufacture of claim 23, wherein the method further
comprises:
setting, at a first loop exit program position, a first reset breakpoint; and
if said first reset breakpoint is satisfied, removing said initial conditional
breakpoint.

26. The article of manufacture of claim 25, wherein the method further
comprises:
if said first reset breakpoint is satisfied, removing said first reset breakpoint.

27. The article of manufacture of claim 25, wherein the method further comprises:
setting, at a second loop exit program position, a second reset breakpoint; and
if one of said first and second reset breakpoints is satisfied, removing said initial conditional breakpoint.

28. The article of manufacture of claim 27, wherein the method further comprises:
if one of said first and second reset breakpoints is satisfied, removing said first and second reset breakpoints.

29. The article of manufacture of claim 23, wherein said first Boolean expression is partially invariant within the loop, and the method further comprises:
extracting, from program code within the loop, a second Boolean expression that is invariant within the loop,
wherein said special conditional breakpoint disjunctively includes the complement of said second Boolean expression, and said first Boolean expression is invariant within the loop when said second Boolean expression is satisfied.

30. The article of manufacture of claim 29, wherein the method further comprises:
setting, at a first loop exit program position, a first reset breakpoint; and
if said first reset breakpoint is satisfied, removing said initial conditional breakpoint.

31. The article of manufacture of claim 30, wherein the method further

comprises:

if said first reset breakpoint is satisfied, removing said first reset breakpoint.

32. The article of manufacture of claim 30, wherein the method further

comprises:

setting, at a second loop exit program position, a second reset breakpoint; and

if one of said first and second reset breakpoints is satisfied, removing said

initial conditional breakpoint.

33. The article of manufacture of claim 32, wherein the method further

comprises:

if one of said first and second reset breakpoints is satisfied, removing said first
and second reset breakpoints.

34. A program debugger, for use in a programming environment, comprising:

means for extracting, from an initial conditional breakpoint within a program
loop, a first Boolean expression that is at least partially invariant within the loop;

means for setting, at a pre-ICB program position, a special conditional
breakpoint that includes the complement of said first Boolean expression; and

means for removing said initial conditional breakpoint if said special
conditional breakpoint is satisfied.

35. The program debugger of claim 34, wherein said first Boolean expression

is completely invariant within the loop.

1 36. The program debugger of claim 34, further comprising:
2 means for setting, at a first loop exit program position, a first reset breakpoint;
3 and
4 means for reestablishing said initial conditional breakpoint if said first reset
5 breakpoint is satisfied.

1 37. The program debugger of claim 36, further comprising:
2 means for removing said first reset breakpoint if said first reset breakpoint is
3 satisfied.

1 38. The program debugger of claim 36, further comprising:
2 means for setting, at a second loop exit program position, a second reset
3 breakpoint; and
4 means for reestablishing said initial conditional breakpoint if one of said first
5 and second reset breakpoints is satisfied.

1 39. The program debugger of claim 38, further comprising:
2 means for removing said first and second reset breakpoints if one of said first
3 and second reset breakpoints is satisfied.

1 40. The program debugger of claim 34, wherein said first Boolean expression
2 is partially invariant within the loop, and said program debugger further comprises:
3 means for extracting, from program code within the loop, a second Boolean
4 expression that is invariant within the loop,

5 wherein said special conditional breakpoint conjunctively includes said second
6 Boolean expression, and said first Boolean expression is invariant within the loop
7 when said second Boolean expression is satisfied.

1 41. The program debugger of claim 40, further comprising:
2 means for setting, at a first loop exit program position, a first reset breakpoint;
3 and
4 means for reestablishing said initial conditional breakpoint if said first reset
5 breakpoint is satisfied.

1 42. The program debugger of claim 41, further comprising:
2 means for removing said first reset breakpoint if said first reset breakpoint is
3 satisfied.

1 43. The program debugger of claim 41, further comprising:
2 means for setting, at a second loop exit program position, a second reset
3 breakpoint; and
4 means for reestablishing said initial conditional breakpoint if one of said first
5 and second reset breakpoints is satisfied.

1 44. The program debugger of claim 43, further comprising:
 2 means for removing said first and second reset breakpoints if one of said first
 3 and second reset breakpoints is satisfied.

1 45. A method of reducing debugger impact through conditional breakpoint
 2 motion, comprising:
 3 extracting, from an initial conditional breakpoint within a program loop, a first
 4 Boolean expression that is at least partially invariant within the loop;
 5 setting, at a pre-ICB program position, a special conditional breakpoint that
 6 includes the complement of said first Boolean expression; and
 7 if said special conditional breakpoint is satisfied, removing said initial
 8 conditional breakpoint.

1 46. The method of claim 45, wherein said first Boolean expression is
 2 completely invariant within the loop.

1 47. The method of claim 45, further comprising:
 2 setting, at a first loop exit program position, a first reset breakpoint; and
 3 if said first reset breakpoint is satisfied, reestablishing said initial conditional
 4 breakpoint.

1 48. The method of claim 47, further comprising:
 2 if said first reset breakpoint is satisfied, removing said first reset breakpoint.

1 49. The method of claim 47, further comprising:
 2 setting, at a second loop exit program position, a second reset breakpoint; and
 3 if one of said first and second reset breakpoints is satisfied, reestablishing said
 4 initial conditional breakpoint.

1 50. The method of claim 49, further comprising:
 2 if one of said first and second reset breakpoints is satisfied, removing said first
 3 and second reset breakpoints.

1 51. The method of claim 45, further comprising:
 2 extracting, from the program code within the loop, a second Boolean
 3 expression that is invariant within the loop,
 4 wherein said special conditional breakpoint conjunctively includes said second
 5 Boolean expression, and said first Boolean expression is invariant within the loop
 6 when said second Boolean expression is satisfied.

1 52. The method of claim 51, further comprising:
 2 setting, at a first loop exit program position, a first reset breakpoint; and
 3 if said first reset breakpoint is satisfied, reestablishing said initial conditional
 4 breakpoint.

1 53. The method of claim 52, further comprising:
 2 if said first reset breakpoint is satisfied, removing said first reset breakpoint.

54. The method of claim 52, further comprising:
setting, at a second loop exit program position, a second reset breakpoint; and
if one of said first and second reset breakpoints is satisfied, reestablishing said
initial conditional breakpoint.

55. The method of claim 54, further comprising:
if one of said first and second reset breakpoints is satisfied, removing said first
and second reset breakpoints.

56. An article of manufacture comprising a computer program medium
readable by a computer and embodying one or more instructions executable by the
computer to perform a method of reducing debugger impact through conditional
breakpoint motion, the method comprising:
extracting, from an initial conditional breakpoint within a program loop, a first
Boolean expression that is at least partially invariant within the loop;
setting, at a pre-ICB program position, a special conditional breakpoint that
includes the complement of said first Boolean expression; and
if said special conditional breakpoint is satisfied, removing said initial
conditional breakpoint.

57. The article of manufacture of claim 56, wherein said first Boolean
expression is completely invariant within the loop.

1 58. The article of manufacture of claim 56, wherein the method further
2 comprises:
3 setting, at a first loop exit program position, a first reset breakpoint; and
4 if said first reset breakpoint is satisfied, reestablishing said initial conditional
5 breakpoint.

1 59. The article of manufacture of claim 58, wherein the method further
2 comprises:
3 if said first reset breakpoint is satisfied, removing said first reset breakpoint.

1 60. The article of manufacture of claim 58, wherein the method further
2 comprises:
3 setting, at a second loop exit program position, a second reset breakpoint; and
4 if one of said first and second reset breakpoints is satisfied, reestablishing said
5 initial conditional breakpoint.

1 61. The article of manufacture of claim 60, wherein the method further
2 comprises:
3 if one of said first and second reset breakpoints is satisfied, removing said first
4 and second reset breakpoints.

62. The article of manufacture of claim 56, wherein the method further comprises:
extracting, from the program code within the loop, a second Boolean expression that is invariant within the loop,
wherein said special conditional breakpoint conjunctively includes said second Boolean expression, and said first Boolean expression is invariant within the loop when said second Boolean expression is satisfied.

63. The article of manufacture of claim 62, wherein the method further comprises:
setting, at a first loop exit program position, a first reset breakpoint; and
if said first reset breakpoint is satisfied, reestablishing said initial conditional breakpoint.

64. The article of manufacture of claim 63, wherein the method further comprises:
if said first reset breakpoint is satisfied, removing said first reset breakpoint.

65. The article of manufacture of claim 63, wherein the method further comprises:
setting, at a second loop exit program position, a second reset breakpoint; and
if one of said first and second reset breakpoints is satisfied, reestablishing said initial conditional breakpoint.

- 1 66. The article of manufacture of claim 65, wherein the method further
- 2 comprises:
- 3 if one of said first and second reset breakpoints is satisfied, removing said first
- 4 and second reset breakpoints.

09897608-070301